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PATENT SPECIFICATION

(11) 1 480 002

(21) Application No. 38828/75 (22) Filed 22 Sept. 1975
(31) Convention Application No. 2446805 (32) Filed 1 Oct. 1974 in
(33) Federal Republic of Germany (DT)
(44) Complete Specification published 20 July 1977
(51) INT CL² F04B 9/04//11/00 49/00
(52) Index at acceptance
F1A 1A1B 1A5 1B8A 1B8B

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(54) PUMPS

(71) We, LEWA HERBERT OTT K.G., a German Company of 725 Leonberg bi Stuttgart, Ulmer Strasse 10, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to pumps, particularly (but not exclusively) dispensing pumps.

A known pump comprises two oppositely reciprocating plungers which, during movement in an induction direction to effect an induction stroke, are each subject to the action of a thrust spring and which, during movement in a displacement direction to effect a displacement stroke, are each in operative connection with a respective one of two cams mounted on a drive shaft and offset by 180° with respect to each other, the cams each having a cam surface and each cam surface having a positive zone for controlling movement of the associated plunger in the displacement direction and a negative zone for controlling movement of the associated plunger in the induction direction.

Such a pump operates with at least two pump heads which may be constructed as plunger or diaphragm pump heads. The reciprocating movement of the plungers is produced on the one hand by lifting action of the cams mounted on the drive shaft and on the other hand by the thrust or compression springs which serve as restoring springs.

In the known pump the cams, which are offset by 180° with respect to each other, are so constructed that the sum of the speeds of the two plungers is constant in the displacement direction, that is to say the so-called positive direction. Such a pump has the disadvantage that while it produces a pulsation-free delivery, it does so only at very low working pressures. At higher pressures, due to the elasticity of the working chambers in the pump heads and due to the compressibility of the fluid being delivered during the transference of delivery from one pump head to the other, there is a transient drop in quantitative flow due to the fact that a certain part of the displacement stroke of the plunger is taken up with applying the necessary pre-compression to the fluid in the working chamber so that it attains the working pressure. This extent of the displacement stroke of the plunger for pre-compression is dependent upon the working pressure and the compressibility of the medium being delivered and is therefore not constant. By reason of the elasticity of the working chamber and the compressibility of the medium being delivered, moreover, the mean quantitative flow is dependent upon the particular working pressure at any given time.

According to the present invention, a pump comprises two oppositely reciprocating plungers housed in respective pump heads and which, during movement in an induction direction to effect an induction stroke, are each subject to the action of a thrust spring and which, during movement in a displacement direction to effect a displacement stroke, are each in operative connection with a respective one of two eccentric cams mounted on a drive shaft and offset by 180° with respect to each other, each cam having an eccentric cam surface on its periphery and each cam surface having a positive zone for controlling movement of the associated plunger in the displacement direction and a negative zone for controlling movement of the associated plunger in the induction direction, the positive zones of the cam surfaces being so configured that the sum of the speeds of the plungers in the displacement direction is constant, and the positive zone of each cam surface having a working zone for performance of the displacement stroke and, outside of the working zone, a separate pre-compression zone for performing a pre-compression stroke, the pump including stroke adjustment means acting on the lengths of the induction strokes of the plungers, and therefore on the extent of filling of the pump heads, to enable adjustment of the pre-compression strokes in dependence on the delivery pressure and the compressibility of the medium being delivered in such a way that

the pump is substantially unaffected in its delivery performance by the delivery pressure and the compressibility of the medium being delivered so as always to deliver a substantially constant flow that is substantially free from pulsations.

In other words, in the present pump part of each cam surface which produces a plunger movement in the positive direction, that is to say in the displacement direction, and which is normally constructed as an Archimedean spiral with parabolic transitions, is so constructed that the working zone and the pre-compression zone are formed. The positive zones, as mentioned above, are so configured that the sum of the plunger speeds of the displacement direction is constant. The relationship governing the speeds of the pre-compression zone of each cam may be determined as desired. Each pre-compression zone serves to build up in the pump head, prior to the actual displacement stroke, a pressure corresponding to the working pressure, the working pressure being attained at that position of the cam at which the pre-compression zone merges into the working zone. In this way, it is ensured that upon the transition of delivery from one pump head to the other, there is no substantial drop in quantitative flow, since at this moment the plunger which is commencing work has by reason of the pre-compression zone of the cam already reached a position in which it starts to operate at the working pressure. The pump thus provides a substantially pulsation-free output and the quantitative flow produced at any given time is substantially independent of the working pressure.

Since, according to the working pressure and the compressibility of the medium being delivered, different travels of the plungers are required, the plunger travel needed for pre-compression is, as set forth above, adjustable. This is effected by means of the stroke adjusting means with which the travel of each plunger is limited in the induction direction, e.g. by stops or abutments. When this happens, the end face of the plunger which co-operates with the cam lifts off the cam and does not again engage the cam until the cam attains that position in which the pre-compression travel is just sufficiently great that upon transition from the pre-compression zone into the working zone, the pump head has been brought to the working pressure.

The stroke adjustment achieved by means of the stroke adjusting means and corresponding to one definite operating condition can be attained or varied manually or automatically. In the case of manual adjustment, each of the required stops may be constructed as a set screw disposed on the pump housing and projecting into the path of movement of the plunger and which can be adjusted accordingly by being screwed farther into or out of the housing.

In contrast, with an automatically operating stroke adjusting device, the necessary signal to actuate a positioning drive can be generated via a quantitative flow or pressure measuring device.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a section through a pump in accordance with the invention;

Figure 2 is a graph showing the relationship between the travel of the plungers of the pump and the angle of a drive shaft mounting two cams;

Figure 3 shows one of the two cams in section, at right-angles to the axis of the drive shaft; and

Figure 4 shows the cam in section and as shown in Figure 3, but divided into sectors for calculation of the configuration of the cam.

The pump shown in Figure 1 comprises a housing 1 having connected thereto two identically constructed pump heads 2, 2′ which may be plunger pump heads. A respective plunger 3, 3′ is reciprocatingly movable in each of the pump heads 2, 2′. Respective plunger rods 4, 4′ of the plungers 3, 3′, sealed in the manner shown in Figure 1, project through a respective housing cover 5, 5′ into the interior of the housing 1.

Each plunger rod 4, 4′ has in the vicinity of its free end a respective peripheral flange 6, 6′, against one side of each of which a respective thrust spring 7, 7′ has an end braced. The other ends of the thrust springs 7, 7′ are braced on the insides of the housing covers 5, 5′, respectively.

Furthermore, by means of respective journals 8, 8′, there is mounted in the region of the free end of each plunger rod 4, 4′ a respective freely rotatable roller 9, 9′. The roller 9, 9′ cooperates with respective identical, eccentric cams 10, 10′ in the manner shown in Figure 1. The cams 10, 10′ are spaced at an appropriate distance from each other and are connected to a drive shaft 11 so as to rotate therewith. The drive shaft 11 is rotatably mounted in the housing 1 by means of bearings 12, 13. The cams 10, 10′ are offset by 180° with respect to each other. The peripheries 14, 14′ of the cams 10, 10′ are configured to form eccentric cam surfaces as shown for the cam 10 in Figure 3. In this respect, the cam surface formed by the periphery 14 includes an induction stroke zone, also called a negative zone, which engages the roller 9 during the induction stroke of the plunger 3, when the plunger moves in the induction direction (downwards in Figure 1). During the induction stroke a graph representing the travel of the plunger

3 against the angle of the drive shaft 11 has a negative slope, as shown in Figure 2. The rest of the cam surface formed by the periphery 14 is a so-called positive or displacement zone: when this zone engages the roller 9 the plunger 3 is moved in the displacement direction (upwards in Figure 1) and the plunger travel-drive shaft angle graph has a positive slope as shown in Figure 2. As Figure 3 shows, the positive zone of the cam surface formed by the periphery 14 of the cam 10 is divided into a working zone and a pre-compression zone. The pre-compression zone is located, in the direction of rotation of the cam 10 as shown by an arrow A in Figure 3, immediately after the induction stroke zone, while the pre-compression zone is followed by the working zone. The pre-compression zone extends over an angle θ of about 60° to 70° of the periphery 14 and is so configured that the plunger 3 is in its working pressure position when the roller 9 engages the cam 10 at the transition point between the pre-compression zone and the working zone.

By reason of the identical construction of the cams 10 and 10′, the foregoing description of the cam surface formed by the periphery 14 of the cam 10 applies also to the cam surface formed by the periphery 10′ of the cam 10′.

Since working pressure and compressibility of various media are of various magnitudes, the amount of travel of the plungers 3, 3′ during the pre-compression stroke may be varied in accordance therewith. This is achieved by means of a respective stroke adjusting device associated with each plunger 3, 3′ and which in the case of the illustrated embodiment, is manually adjustable, being constructed as an adjusting set screw 15, 15′ mounted on the housing 1. Each adjusting set screw 15, 15′ projects into the interior of the housing 1 and also, in an axial direction, into the path of the associated plunger 3, 3′ or plunger rod 4, 4′ and cooperates with the peripheral flange 6, 6′ of the associated plunger rod 4, 4′ in the manner shown in Figure 1. By screwing the set screws 15, 15′ farther into or farther out of their seatings, it is possible for the peripheral flanges 6, 6′ to abut earlier or later against the free ends of the set screws 15, 15′, so that the induction strokes of the plungers 3, 3′ are limited or terminated, the rollers 9, 9′ being out of engagement with the cam surfaces formed by the peripheries 14, 14′ of the cams 10, 10′ for correspondingly long periods. When the pump is set in operation, the travel of the plungers 3, 3′, plotted against the angle of the drive shaft 11, is as shown in Figure 2, from which it is manifest that a substantially competely pulsation-free quantitative flow can be produced by the twin pump described. As can be seen, the working zones of the cam surface formed by the peripheries 14, 14′ of the cams 10, 10′, are so configured that the sum of the speeds of the plungers 3, 3′ is constant in the displacement direction. In contrast, the speed law of the relevant pre-compression zone of each cam 10, 10′ can be constructed as desired.

By virtue of the fact that each cam 10, 10′ has a pre-compression zone, it is in any case ensured that the plungers 3, 3′ are in their working pressure positions immediately the rollers 9, 9′ engage the corresponding cam 10, 10′ in the appropriate transition zon between the pre-compression zone and the working zone. The stroke adjusting devices make it possible to adapt to various working pressures and compressibilities of different media which have to be delivered by the pump. All in all, therefore, a substantially completely pulsation-free flow is guaranteed in every case whereby, moreover, the flow pressure generated by the pump is independent.

An example of how the configurations of the cam surfaces formed by the peripheries 14, 14′ of the cams 10, 10′ can be calculated is given hereinafter with reference to Figure 4. The following different equations apply to individual sectors I to V of the cams 10, 10′ shown in Figure 4:

Sector I

$$\varphi=0 \rightarrow \varphi_0 : r=r_0+a\varphi^2$$

Sector II

$$\varphi=\varphi_0 \rightarrow \pi : r=r_0+a\varphi_0{}^2+b(\varphi-\varphi_0)$$

Sector III

$$\varphi=\pi \rightarrow (\pi+\varphi_0+\varphi_1) : r=r_1-a(\pi+\varphi_0-\varphi)^2$$

Sector IV

$$\varphi=(\pi+\varphi_0+\varphi_1) \rightarrow (\pi+\varphi_0+2\varphi_1+\varphi_2) : r=r_2+a(\pi+\varphi_0+2\varphi_1-\varphi)^2$$

Sector V

$$\varphi=(-\varphi_2) \rightarrow 0 : r=r_0-a\varphi^2$$

Numerical values:

$a=5.99305$ mm; $\varphi_0=0.15934$; $r_0=24.5$ mm

$b=1.90987$ mm; $\varphi_1=0.91340$; $r_1=30.5$ mm

$\varphi_2=0.57769$; $r_2=20.5$ mm

The above-described pump can be modified within the scope of the invention as defined by the appended claims. For instance the stroke adjusting devices can be replaced by or modified to form a stroke adjusting means controlled automatically by a positioning drive means which can be actuated by means responsive to the pump output, for instance, a quantitative flow measuring device or a pressure measuring device.

WHAT WE CLAIM IS:—

1. A pump comprising two oppositely reciprocating plungers housed in respective pump heads and which, during movement in an induction direction to effect an induction stroke, are each subject to the action of a thrust spring and which, during movement in a displacemnt direction to effect a displacement stroke, are each in operative connection with a respective one of two eccentric cams mounted on a drive shaft and offset by 180° with respect to each other, each cam having an eccentric cam surface on its periphery and each cam surface having a positive zone for controlling movement of the associated plunger in the displacement direction and a negative zone for controlling movement of the associated plunger in the induction direction, the positive zones of the cam surfaces being so configured that the sum of the speeds of the plungers in the displacement direction is constant, and the positive zone of each cam surface having a working zone for performance of the displacement stroke and, outside of the working zone, a separate pre-compression zone for performing a pre-compression stroke, the pump including stroke adjustment means acting on the lengths of the induction strokes of the plungers, and therefore on the extent of filling of the pump heads, to enable adjustment of the pre-compression strokes in dependence on the delivery pressure and the compressibility of the medium being delivered in such a way that the pump is substantially unaffected in its delivery performance by the delivery pressure and the compressibility of the medium being delivered so as always to deliver a substantially constant flow that is substantially free from pulsations.

2. A pump according to claim 1, wherein the pre-compression zone of each said cam surface embraces an angle of about 60° to 70° of the cam surface.

3. A pump according to claim 1 or claim 2, wherein the stroke adjusting means comprises a respective stop disposed in the path of movement of each plunger and movable axially of said path to limit the induction strokes of the plungers by adjustable amounts.

4. A pump according to claim 3, wherein the pump has a housing and each said stop is constructed as a set screw disposed on the housing and projecting into said path of movement of the associated plunger.

5. A pump according to claim 1 or claim 2, including a flow or pressure measurement device responsive to the output from the pump and positioning drive means actuated by the device to automatically adjust the stroke adjusting means.

6. A pump substantially as herein described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 480 002 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

Fig.1

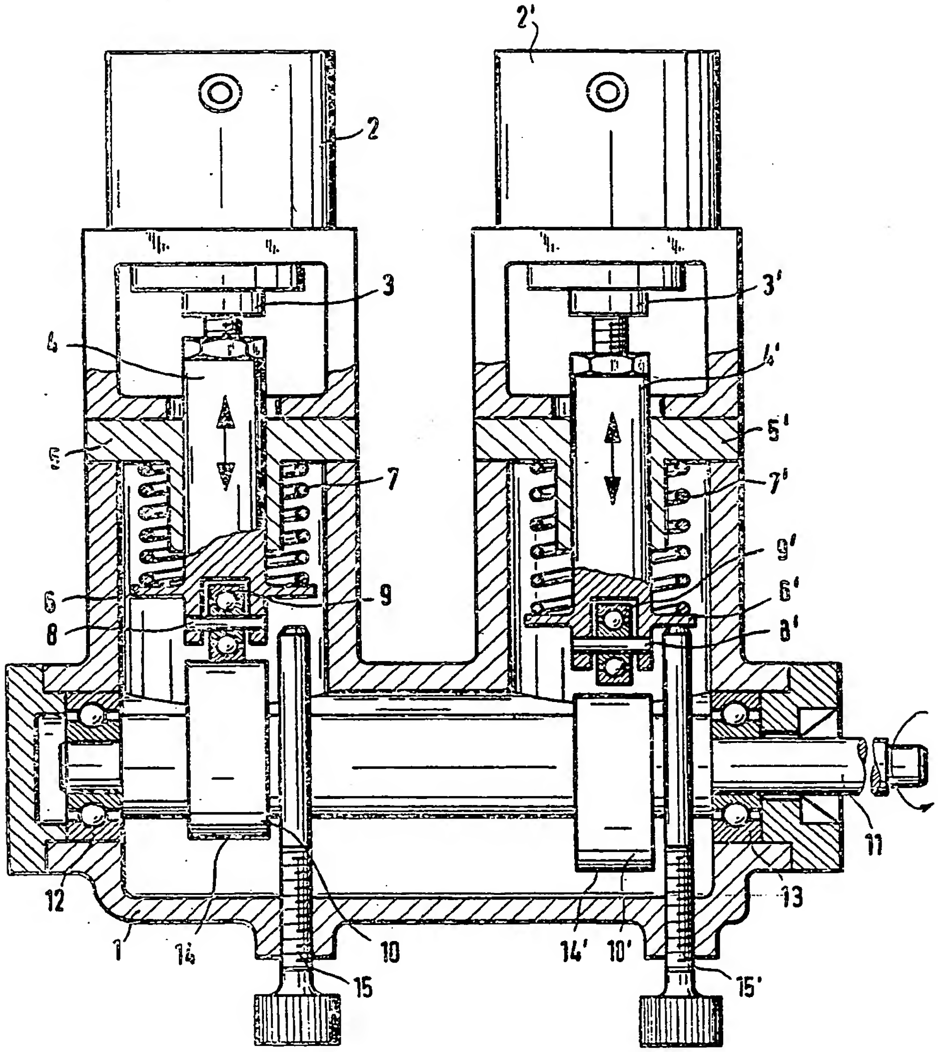


Fig. 2

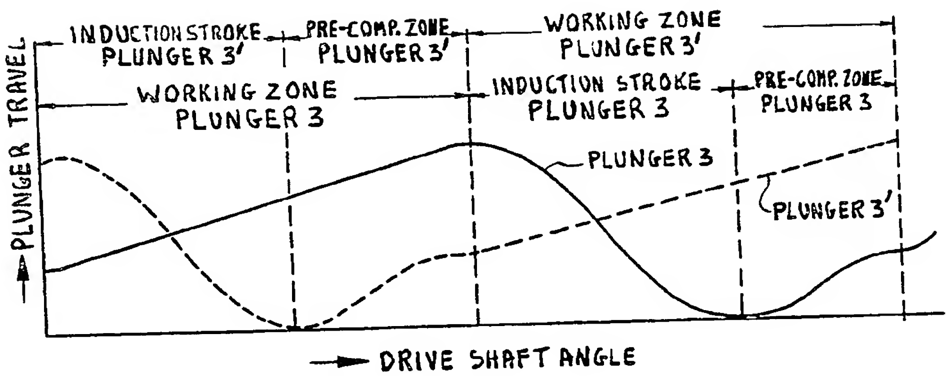
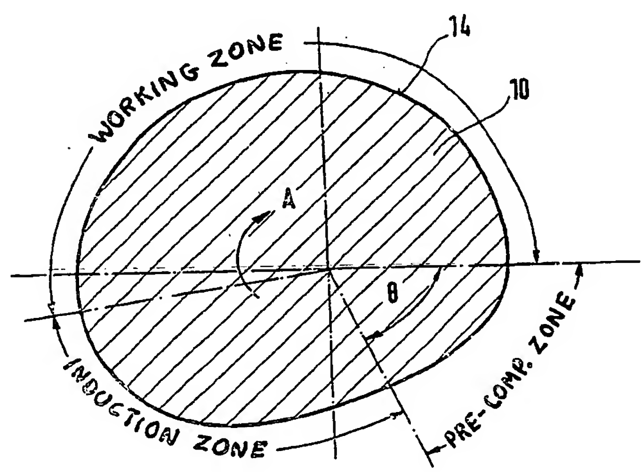

INDUCTION STROKE PLUNGER 3'
PRE-COMP. ZONE PLUNGER 3'
WORKING ZONE PLUNGER 3'
WORKING ZONE PLUNGER 3
INDUCTION STROKE PLUNGER 3
PRE-COMP. ZONE PLUNGER 3
PLUNGER 3
PLUNGER 3'
PLUNGER TRAVEL
DRIVE SHAFT ANGLE

Fig. 3


WORKING ZONE
14
10
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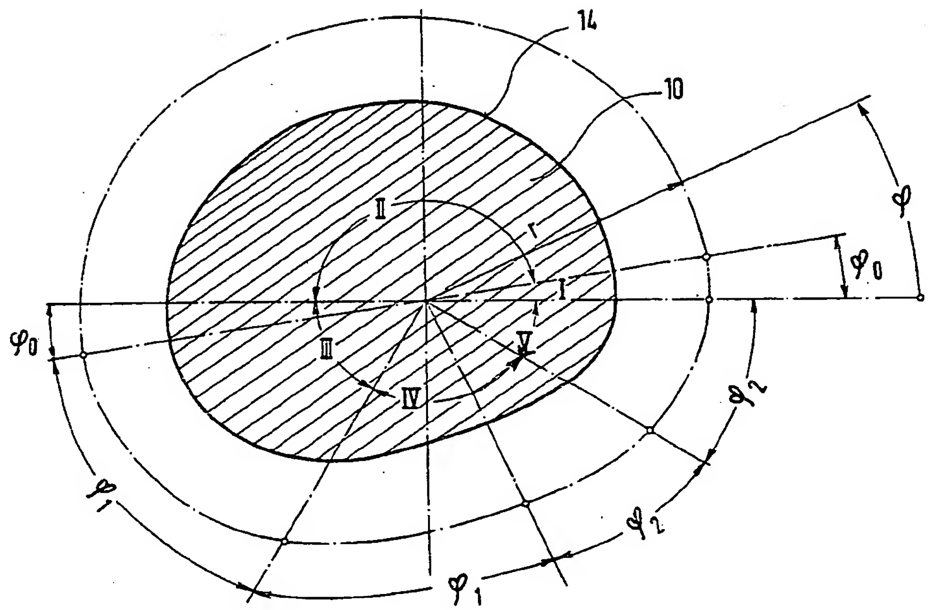
PRE-COMP. ZONE
INDUCTION ZONE

Fig. 4


14
10
I
II
III
IV
V
r
φ
φ_0
φ_0
φ_1
φ_1
φ_2
φ_2